EFFECT OF POLARISED TRAINING ON PHYSICAL AND SKILL PERFORMANCE IN ELITE AND SUB-ELITE BADMINTON PLAYERS

SHORT SYNOPSIS

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Certificate

I hereby declare that the short synopsis "Effect of polarized training on physical and skill performance in elite and sub-elite badminton players" being submitted in partial fulfillment of the requirement for the degree of **Doctor of Philosophy in physiotherapy under the School of Allied Health Sciences of Manav Rachna International institute of research & studies, Faridabad** during the academic year 2021-22. It is a bonafide record of original work carried out under the supervision of Dr. Nitesh Malhotra and has not been submitted in full or part to any other university or institute for a degree or diploma. Further, it is certified that the short synopsis is plagiarism free and the proof has been submitted.

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ABSTRACT

Effect of polarized training on physical and skill performance in elite and sub-elite badminton players

Background/Introduction: Badminton is a highly competitive game that requires a good endurance level along with a rapid change in direction and the ability to hit the shuttle in the desired direction. Polarised training is an innovative endurance training program that involves spending more time in low-intensity training (to avoid injury and develop skill level), very less time in threshold level intensity (for balance and coordination), and less time in high-intensity training (combining balance and coordination with the skill along with rapid start-stop movements).

Objectives: This study aims to measure the effect of polarised training on the agility, game skill, endurance, and hand-eye coordination of elite and sub-elite badminton players.

Methodology: The methodology followed will consist of an experimental study design (pretest–posttest) which will include one experimental or polarized training group and one control or usual training group. A total of 80 subjects will be selected as per the stated inclusion-exclusion criteria and randomly categorized into one of the aforementioned groups (n=40). In the polarised training group, there will be an identification of their low-intensity, threshold-intensity, and high-intensity level followed by a 9-week training program. In the control group, players will continue their regular training under the guidance of their coach and no interference will be done by the researcher. Pretest and post-test outcome measures will be taken before and after the training is complete in the respective groups.

Expected outcome: It is expected that polarised training may be more effective in improving the player's agility, endurance, skill, and hand-eye coordination as it is effective in various other endurance sports.

Keywords: Polarised training, agility, endurance, hand-eye coordination and blood lactate level.

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INTRODUCTION

Badminton is an extremely competitive sport that involves a rapid variety of different body movement techniques in a relatively small area (Hughes, Reilly, & Lees, 1995). Each game set requires high-intensity movements with small rest periods involving swift coordination of both the lower and upper extremities (Faude et al., 2007). An athlete is required to do sprints, stops, starts, lunges, jumps (Nadzalan, Mohamad, Lee &Chinnasee, 2018), and rapid changes of direction, twists, stretches, and smashes to win the game (Jeffry & Mohamad, 2013). The players must have a swift response to the movement of the shuttle and the strokes of their opponents (Abdullah et al., 2018).

The physical requirements of a badminton player comprise several fitness components like muscular endurance, coordination, and agility (Lees, 2003). Recently, the variation in training intensities is used as a tool to increase biological adaptations (Stoggl&Sperlich, 2014) and hence one's athletic performance to gain a competitive advantage over others. (Stoggl&Sperlich,2015).

Traditional models of training include:

- Low-intensity training.
- Threshold-intensity training.
- High-intensity training.

An innovative variable intensity training program known as polarised training which is a combination of the above-mentioned training types has gained popularity among athletes worldwide. The model elaborated that threshold training which is nearer to an athlete's lactate threshold is unproductive. It recommends that the endurance of the athletes would be better if they spend most of their training time working at low intensity (Zone-1) and a small percentage at a very high intensity (Zone-3) with very little or no time spent in training at lactate threshold (Zone-2) (Stoggl&Sperlich, 2014; Stoggl&Sperlich,2015).

Zone	Energy System Used	Heart Rate	Blood Lactate Level
1	Aerobic System (Low intensity)	Under 80% of HR max	Less Than 2 mmol/liter
2	Aerobic & anaerobic (Threshold intensity)	80 – 85% of HR max	2-4 mmol/liter
3	Mainly Anaerobic (High intensity)	Over 85% HR max	More than 4 mmol/liter

Table 1 shows HR and blood lactate levels when different energy systems are used.

The blood lactate level and heart rate are the two criteria's according to which these different training zones are being distinguished. As the power output or exercise intensity increases there is a relative increase in the blood lactate level. LT1 which is the first lactate turn point defines the exercise load at which the blood lactic acid level becomes substantially higher than the resting levels. Similarly, LT2 is defined as the second lactate turn point, which is the load at which the lactic acid rises rapidly or where the rate of lactate accumulation>>> lactate clearance. LT1 reflects an increased contribution to activity from glycolysis and LT2 indicates that the aerobic system is unable to match the energy requirement. (Stoggl & Sperlich, 2014; Seiler & Kjerland, 2006; Hydren& Cohen, 2015).

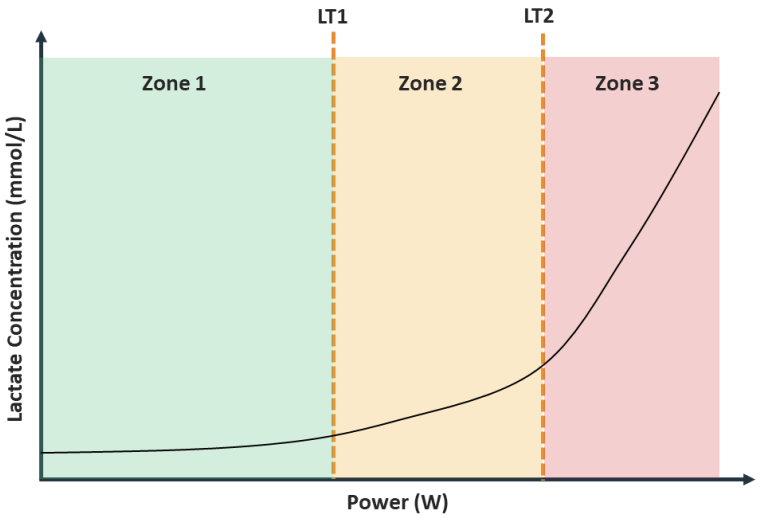

Fig 1:Graph depicting the relationship between blood lactate level and power output.

Research was done on endurance athletes like cyclists (Neal et al., 2013) and runners (Munoz et al., 2014; Esteve-Lanao, Earnest, Foster & Lucia 2005; Esteve-Lanao, Foster & Lucia 2007)has shown polarised training to be superior to other training models but it is still unexplored in sports like badminton.

Problem statement

Polarised training has been adopted by various elite athletes in sports like running, cycling, rowing; skiing, etc. to enhance their performance but no research has been done on badminton players to identify their sports-related polarised training protocol and its effects on the performance of the players.

Aim of the study

The aim of the present study is to find the effect of polarised training on badminton players.

Objectives of the study:

- To evaluate the outcome of polarised training on the agility of badminton players.
- To evaluate the outcome of polarised training on the game skill of badminton players.
- To evaluate the outcome of polarised training on the endurance of badminton players.
- To evaluate the outcome of polarised training on the hand-eye coordination of badminton players.

RESEARCH HYPOTHESIS

- There will be a significant difference in the agility of badminton players due to polarised training.
- There will be a significant difference in the game skill of badminton players due to polarised training.
- There will be a significant difference in the leg speed endurance of badminton players due to polarised training.
- There will be a significant difference in hand-eye coordination of badminton players due to polarised training.

NULL HYPOTHESIS

- There will not be a significant difference in the agility of badminton players due to polarised training.
- There will not be a significant difference in the game skill of badminton players due to polarised training.
- There will not be a significant difference in the leg speed endurance of badminton players due to polarised training.
- There will not be a significant difference in hand-eye coordination of badminton players due to polarised training.

OPERATIONAL DEFINITIONS

- Polarised training: Training schedule in which the amount of time spent in low-intensity training is 70-80%, in threshold intensity training is 0-5% and in high-intensity training is 20-25%.
- Low-intensity training: During training, blood lactate remains between 0-2 mmol/L.
- Threshold intensity training: During training, blood lactate remains between 2-4 mmol/L.
- High-intensity training: During training, blood lactate remains above 4 mmol/L.
- Badminton players:
    - Elite badminton player: National-level players.
    - Sub-elite badminton player: District or zonal players.

REVIEW OF LITERATURE

Change in the trend towards polarised training

The traditional training method followed by athletes was the threshold model which was believed to be the game-level intensity. This meant that most of the training was done at the lactate threshold and was thought to have maximum game-like stress and simulate the best exercise adaptations. However, few observation researches were done on the actual training practice of elite athletes from different sports and countries and it was found that these athletes were allocating a larger portion of time by training at low intensities, followed by training at the high-intensity level and minimizing the time spent on threshold training. This indicates a change from the traditional training model to the new polarised training model.

Research done by **Orie J., Hoffman N., Koning J. & Foster C. (2014)** were successful in concluding that there is a change in the training models of Olympic speed skaters over a time frame of 38 years. The threshold periodization training model followed by the players in 1972 has given way to the polarised training model by 2010.

Fiskerstrand A. & Seiler K.S.(2004) reported that from 1970 to 2001 there was a change in the training strategy of international rowers. Just by increasing the training time spent in zone-1 (80% increase) and decreasing the time spent in zone-2 and -3 (decrease by 60%); there was a rise in the oxygen consumption levels (12%) in these athletes and hence resulting in an increase in performance.

Identification of training distribution followed by elite athletes

Seiler K. & Kjerland O. (**2006)** recorded the duration of time spend in different types of exercise training intensities of cross-country skiers (N=11). They kept a track of their training for 32 days. The conclusion was that they were training in 3 zones, with 75% of training time in zone-1, 5-10% in zone-2, and 15-20% in zone-3 which is similar to the parameters of polarised training model.

Billat et al. (2001) concluded that elite-marathon runners for their Olympic qualifying round were training about 78% in zone-1 i.e. running below race pace, 18% in zone-3 i.e. above race pace, and only 4% in zone-2 i.e. at marathon race pace. This training lasted for 12-weeks. This again was found to be similar in training intensity distribution to the polarised training model.

Plews D. J. & Laursen P. B. (2017) did a study from one Olympic Games to the other to compare the training pattern of male rowers. It was done across phases, years, and between individuals from March 2013 to Rio Olympics final in 2016. One rower trained more in the polarised intensity distribution and the other trained more in the pyramidal distribution. However, the training intensity distribution becomes more polarised as moving close to the Olympics. Training intensity distribution was measured with lactate threshold and heart rate.

Comparison of polarised training with other training methods

Kenneally M., Casado A., & Concejero J. (2018) did a systemic review to see the effectiveness of 3-types of training models: pyramidal, polarized and threshold training. It was done to see the effect of these training models on the athletic performance of runners. They also found that pyramidal and polarised models of training intensity distribution are the most used and effective training approach in elite endurance athletes than the threshold training model.

Stöggl T. & Sperlich B. (2014) did a comparison between four types of training models (low-intensity training, threshold-training, high-intensity interval training, and polarised training) in endurance athletes. They concluded that maximum physical exercise performance parameters improved in the polarized training group in nine weeks.

Yu H., Chen X., & Cao C.(2012) conducted a study in which threshold and polarised training were compared in national speed skating teams. The study included the training load of the skating team (5 men and 4 women) for two seasons (2004-5 and 2005-6). Each season's training load was analyzed. Their performance at national and international competitions (world cup and Olympics) was analyzed along with post-competition lactate level. It was found that the threshold model of training was followed during the first season of 2004-5 and the polarised was followed in the second season of 2005-6. Their performance significantly improved in the second season where a polarised training approach was followed along with a decrease in the post-competition lactate level in the same group.

Effect of polarised training

Hebisz P. & Hebisz R., (2021) did research to find out the effects of polarised training on muscle girth and anaerobic power in cyclists. 26 cyclists were divided into an experimental group and a control group (both were done for 9 weeks). The experimental group performed a polarised training model whereas the control group performed high-intensity interval training

and endurance training. They concluded that the experimental group showed a decrease in muscle girt and an increase in anaerobic power. Both these changes are beneficial in cycling.

Brechbuhl C., Girard O. & Schmitt L. (2017) assessed the possibility of implementing a polarised training (75% of sessions in zone-1, 15 % in zone-3 and <10% in zone-2) in tennis. In this sport, the performance of the athlete depends on the ball's velocity and ball accuracy (both in forehand and backhand strokes). They concluded that polarised training may contribute in better planning and management of fatigue. The results of the study are summarized in Table 2.

Training Zones	Zone-1	Zone-2	Zone-3
Training	Stage 16-22 balls/min	Stage 22 – 24 balls/min	Stage 25 – 29 balls/min
Technical Gains	Balance. Energy transfer. Game skill. Short footwork.	Footwork balance. Energy transfer. Coordination between upper & lower body.	Speedy footwork. Balance and coordination. Start-stop movements.
Physical Gains	Muscle's blood supply. Mitochondria. Aerobic & beta-oxidation enzymes.	Transport of hydrogen ions. Use of fat and carbohydrates.	Maximal aerobic frequency of ball hitting. Muscle buffering capacity. Cardiopulmonary capacity. Muscle glycogen stores.

Table 2: Gains achieved in different training zones.

METHODOLOGY

Study design:

Experimental Study design within two groups.

Sampling design:

Simple Random sampling

Study Place:

Badminton Academy/ Sports complex in Delhi/ NCR.

Inclusion Criteria

- Subjects i.e., 16-28 years of elite and sub-elite Indian Badminton players both male and female were taken from Badminton Academies in and around New Delhi NCR.
- The Physical Activity Readiness Questionnaire (PAR-Q) will be used to rule out contraindications to participation.

Exclusion Criteria

- Pregnancy in the case of female badminton players.
- Any recent pain in the back, knees, and ankles.
- No lower/ upper-extremity or lumbar spine surgery within 6 months.
- Athletes who took caffeine/ alcohol or did strenuous exercise 48 hours before the start of the research protocol (Pesta, Angadi, Burtscher& Roberts, 2013).

VARIABLES

- Dependent variable: Polarised training.
- Independent variable:
    - Four corner Agility test.
    - Forehand and backhand test.
    - Yo-Yo intermittent recovery test.
    - Hand-eye coordination

SAMPLE SIZE

It is calculated using the software G. Power (version 3.1.9.7) using the changes in variables VO2 max (L/min) after 9 weeks of polarised training done by Stiggl and Sperlich (2014), the effect size coming out to be 0.47. Considering the same effect size, at power 0.8 and α level 0.05, a sample size of 37 was found for a single group. Adding 10% dropout, a total sample size of 80 (Control Group = 40 & Experimental Group = 40) was found to be necessary to test the hypothesis of the present study.

INSTRUMENTATION

- Blazepod – Trainer kit (6-pods) with application.
- Shuttles- Moderate speed 77.
- Lactate analyzer- Lactospark.
- Smart watch for heart rate measurement- Apple series-3.

PROCEDURE:

Note: Food intake will not be permitted 3h before all testing and training periods. All subjects will be asked to report being well-hydrated. An ambient temperature of 28-32 degrees Celsius will be checked inside the badminton court (Sarhang, 2014).

Step 1

Players will be included in the study based on the inclusion-exclusion criteria. Outcomes measures will be checked before the training after explaining to the players the motive of the research and taking their consent for the same.

Step 2

Players are randomly divided into the polarised training group and the control group.

Step 3

Polarised Training Group

Determination of low-intensity, threshold intensity, and high-intensity protocol for an individual player. Each intensity level is determined on the second day and a fixed warm-up protocol is followed by each player prior to the test. Polarised training starts on the seventh day (9-week protocol) with the same warm-up protocol followed by each player.

Control Group

Players complete regular training that is supplemented by their coach for 9 weeks. (Sarhang 2014; K Suppiah et al., 2020). No interference will be made by the researcher in this group's 9-week training as it will be their regular training as planned by their coaches.

Step 4

Outcome measures are checked again post-intervention.

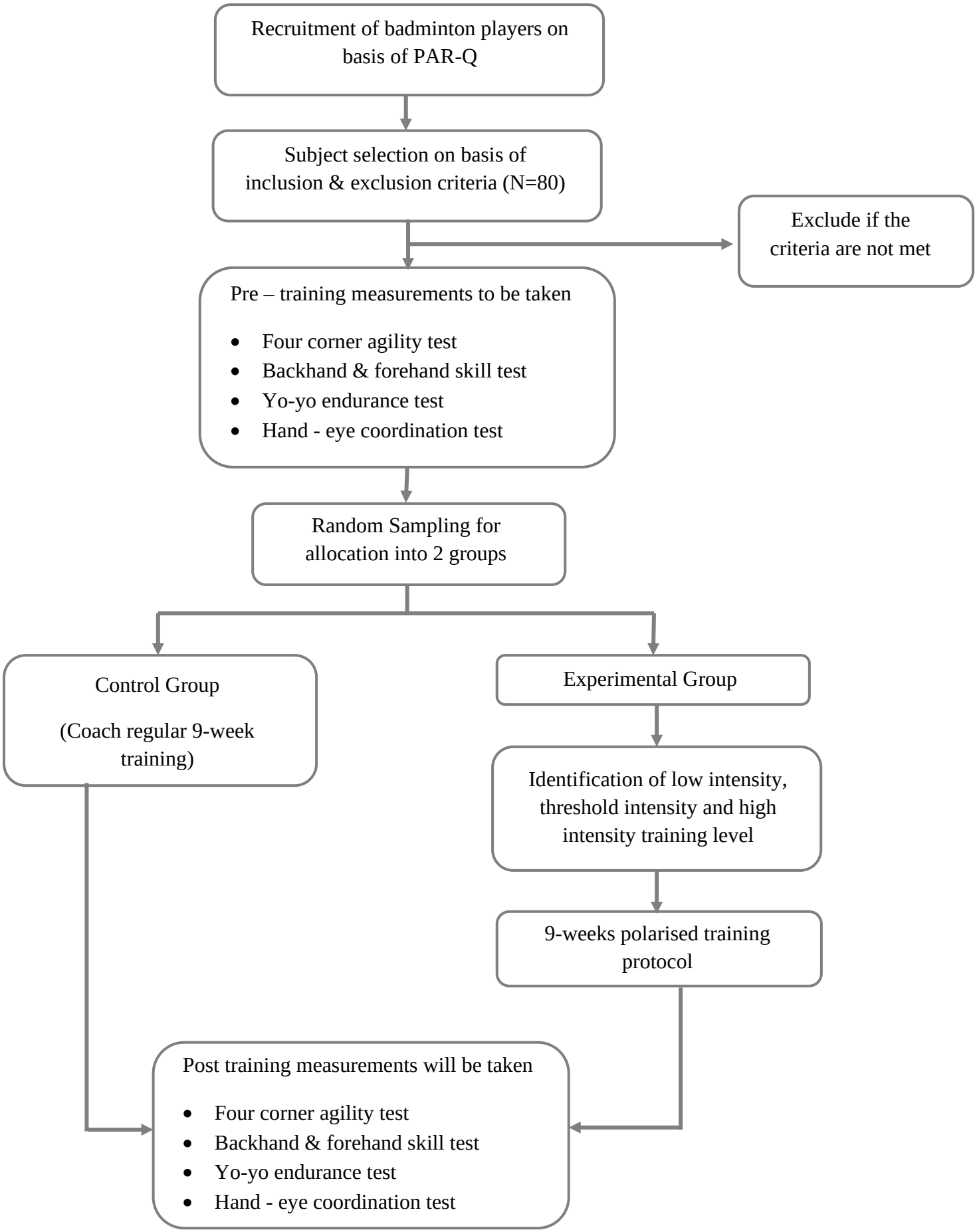
Recruitment of badminton players on basis of PAR-Q
Subject selection on basis of inclusion & exclusion criteria (N=80)
Exclude if the criteria are not met
Pre – training measurements to be taken
Four corner agility test
Backhand & forehand skill test
Yo-yo endurance test
Hand - eye coordination test
Random Sampling for allocation into 2 groups
Control Group
(Coach regular 9-week training)
Experimental Group
Identification of low intensity, threshold intensity and high intensity training level
9-weeks polarised training protocol
Post training measurements will be taken
Four corner agility test
Backhand & forehand skill test
Yo-yo endurance test
Hand - eye coordination test

Fig 2: Flowchart of study design

Polarised Training Group Intervention

In this research polarised training is carried out via badminton field test to replicate the sport-specific movement. This test will be executed on a badminton court. Blazepod training lights will be individually mounted on six posts, with a shuttlecock hanging at each post. These lights will be connected to Blazepod mobile application on the researcher's phone. Two training lights will be located near the forecourt near the net, the next two at the midcourt, and the last two at the rear court. Variation in training intensity is achieved by varying the speed of the Blazepod training lights through its mobile application. The subjects will run from a central point X towards each post where the blazepod training light flashes and will be told to strike the shuttle. For the forecourt and midcourt, subjects will perform lunges. For the rear court flashes, they will perform a backward jump as same for a smash and then return to point X.

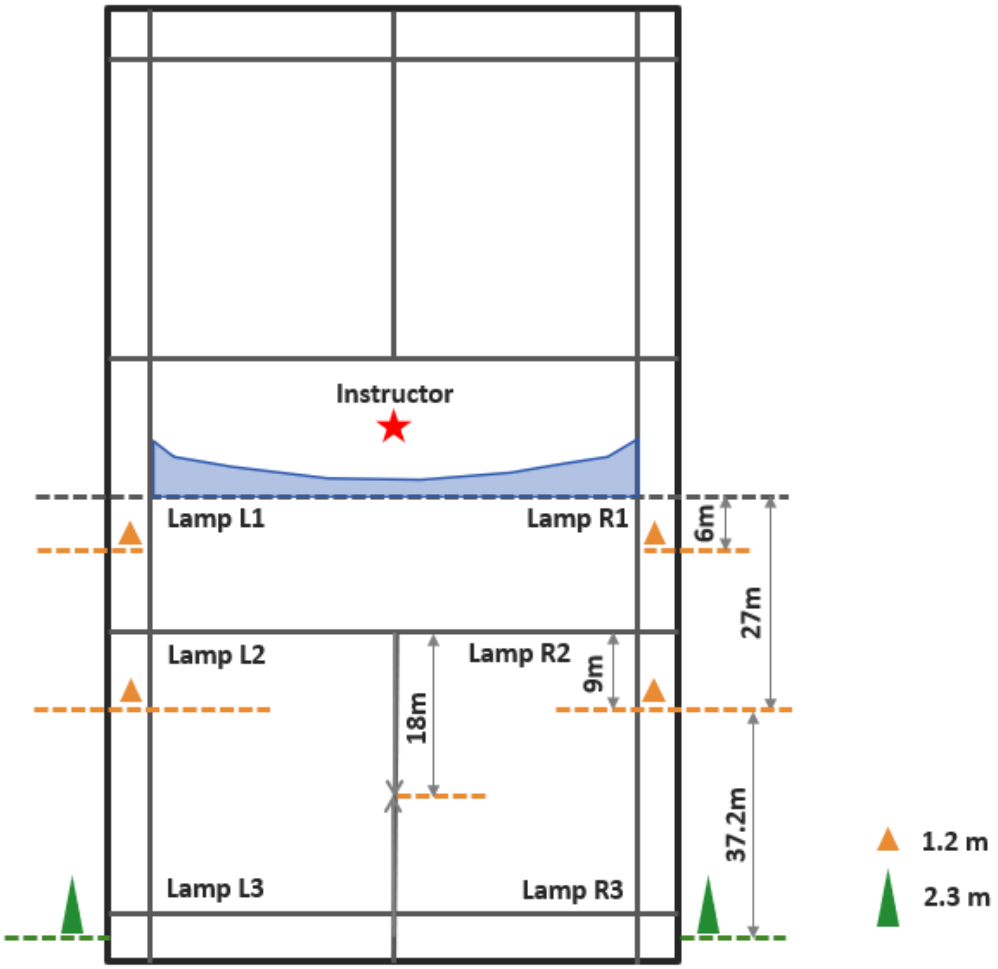

Fig 3: Badminton Field Test

Check for intensity Level Training

The test will consist of multiple levels with each of them consisting of three minutes of exercise followed by a 45 sec rest period. For lactic acid level, blood will be drawn from the tip of the non-dominant arm finger which is defined as the arm not holding the racquet, during a 45-second rest interval between each level. A level of exhaustion is said to be achieved if the next blazepod light flashes before the previous one was touched by the subject. The polarised training will include three blocks of three weeks each: the first two weeks of high-volume and intensity training followed by one week of recovery.

ZONES	ZONE-1	ZONE-2	ZONE-3
LEVEL TRAINING	16 light pulses/ minute	20 light pulses/ minute	22 light pulses/ minute will be increased by 2 pluses/minute at each level (max up to 26 pulses/ min)
ENDPOINT	The lactate level crosses 2mmol/L.	The lactate level crosses 4mmol/L.	Level of exhaustion is achieved (Lactate level is recorded).

Table 3: Training of different zones in the polarised training group.

Outcome Measures:

- Agility: Four corner agility test (K Suppiah et al., 2020; Yuksel& Aydos, 2019; Phosphate et al., 2018; Ooi et al., 2009).
- Player's game skill: Forehand and backhand shot test. (Sarhang, 2014; Tzetzis et al., 2008).
- Endurance: Yo-Yo intermittent recovery test. (Krustrup et al., 2003; Bangsbo et al., 2008; Abian-Vicen et al., 2021).
- Coordination: Hand – Eye coordination test. (Kaur, kumar & Sandhu 2008; Kansal, 2008; Patel et al., 2018).

Four corner agility test:

It will be performed on one-half of the badminton court. It involves diagonal movement action similar to performed during a badminton game with rapid changes in direction. Four shuttlecocks are placed in an upside-down position at each corner of the half-badminton court as seen in the figure below. The subjects will be told to follow a particular sequence order. These sport-specific movements will be performed by the subjects by moving towards the direction of their dominant hand for a start; then followed by striking the up-turned shuttlecock with the racquet. Two trials with 5-minute rest will be performed by each subject. The best performance time of the two trials will be marked as their test result.

The sequence of movement to be followed:

- Right-Handed subjects

  Centre ⟹ A⟹Center⟹B ⟹Center⟹C ⟹Center⟹D ⟹ Center.
- Left-Handed subjects

  Centre ⟹C ⟹Centre ⟹D ⟹Centre ⟹ A ⟹Centre ⟹B ⟹ Centre

  Repeat until the subject will strike all 16 shuttlecocks.

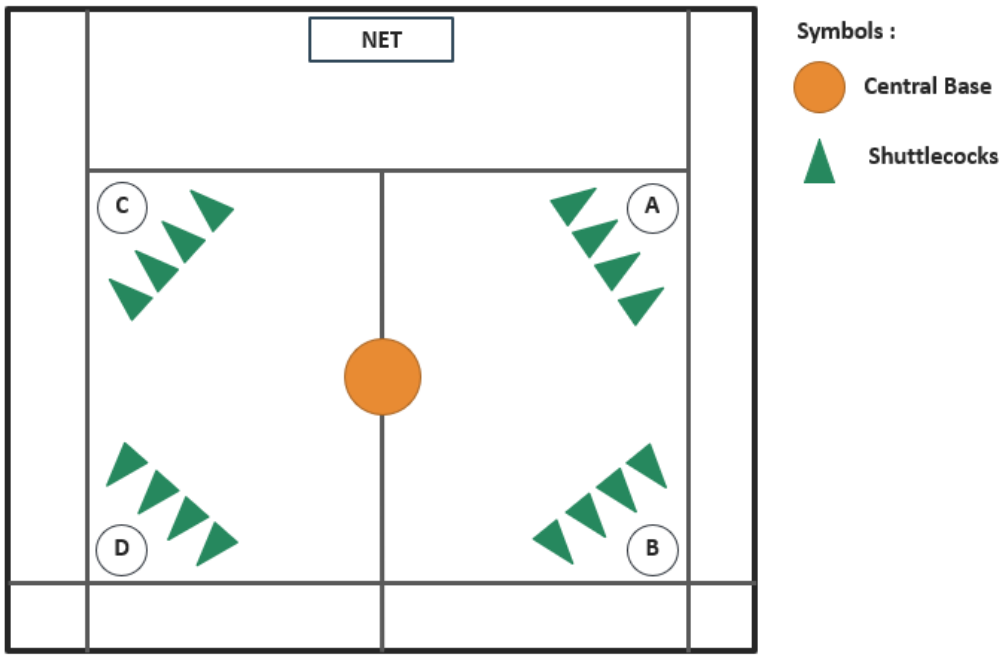

Fig. 4: Set-up for the agility test.

Forehand and backhand test:

The test will measure the ability of the player's skill in the forehand and backhand in badminton. Five zones will be marked on one half of the court as shown. The tester will stand at point B and will serve high at the participant's forehand and backhand. Participants being tested will stand in the opposite court and will try to score maximum points. The score will be awarded when the base of the shuttle first hits the ground. Shuttle going outside the scoring area will be marked as no points. The participants will be given 12 trials of 12 chances each and the best of 10 trials will be the score for each participant.

On-the-line shuttles will be awarded the area with higher points.

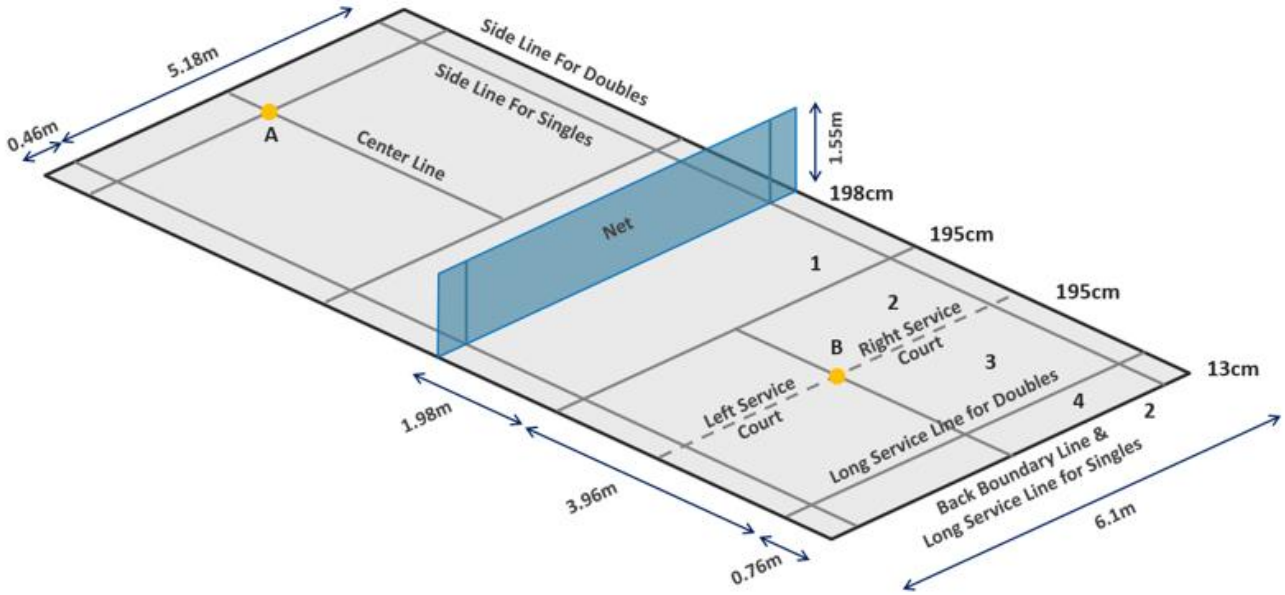

Fig 5: Badminton Court for measuring the ability of the player's skill in the forehand and backhand in badminton.

Yo-Yo Test:

Itis a good tool to measure endurance of athletes in various sports. It consists of running at progressively increasing speed on a 2-m-wide and 20-m-long running track marked by cones. It will start at a speed of 10km/hr. and is controlled by audio beeps from a Yo-yo test application on the researcher's smart phones. There is an active rest period of 10-s between each running bout. When the subject fails to reach the finishing line before the beep twice, the distance covered will representas their result.

Hand-eye coordination test:

The subject will stand facing a wall at a one-meter distance and will throw a table tennis ball toward the wall with one hand and will catch it with the other hand repeatedly for 30 seconds. The subject will be allowed to use overhead, underarm techniques, or a combination of both. This test will also include a training phase in which subjects will get familiar with this procedure as they will practice throwing and catching the table tennis ball six times only.After the training phase, the number of times the subject catches the table tennis ball correctlyin 30 seconds will be registered. This process will be repeated three times and their average will be considered the result.

Ethical considerations

For ethical consideration, the subjects are enrolled after taking the consent for participation and informing them about the purpose of the study. They are informed that they can feel mild soreness or fatigue/ tiredness after the training provided during the study. These are common issues which an athelete can face during his/her training phase and any such discomfort relating to the training provided during the study would also be dealt immediately. Apart from this all precautions would be taken to make sure that the subjects undergoing the training are undergoing proper assessment with their health history and exercise restriction. This study will also be submitted for ethical approval from Institutional Ethical committee.

Expected Outcome

We expect that polarised training may be more effective in improving the player's agility, endurance, skill, and hand-eye coordination as it is effective in various other endurance sports.

APPENDIX:

1. Warm-up (Wee, Low, Chan&Ler 2017;Middleton, Bishop, Smith& Gee2016; Kaur et al.,2008)

   The warm-up protocol consists of 7 minutes of stretching the leg muscles and light jogging. It has 6 dynamic exercise of moderateto high intensity lasting for one minute each with a rest periodof 10 sec.

Table 4: Description of warm-up exercises.

Warm-up exercises	Description
Speed-skips	Do vigorous arm movement with both elbows at 90-degree flexion while skipping forward.
Heel-kicks	Do forward motion by rapidly kicking their heels in the direction of their buttocks as they move ahead.
Toe in, toe out	The individuals quickly hop forward, turning their toes in with their heels turned out, then their toes out with their heels turned in. Hip rotation and movement speed are stressed.
Trunk twists	The subjects put their hands behind their heads and jump quickly forward, twisting their hips to the right and left. They accelerate the trunk rotation while maintaining an erect posture with the chest forward.
Push-ups	The individuals start in a modified push-up stance with their knees on a mat and their hands close to their chest. They then do 3 controlled-speed pushups, followed by 3 more.
High knee skips	The subjects increase the height of each forward skip, lift their knees high, and vigorously use both elbows at 90-degree flexion while skipping forward.

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Changes or queries raised in DRC

S.No.	Query or change advised	Correction Done
1.	Registration number to be changed	YES
2.	Faculty of allied health sciences to School of allied health sciences	YES
3.	Justify: Lactate threshold training is unproductive	YES
	Ref.: (Stoggl & Sperlich 2014; Pla, R., Le Meur, Y., Aubry, A., Toussaint, J. F., & Hellard, P. 2019)	
4.	Heart rate as a criteria for distinguishing zones of training	YES
	Ref. already done in the paragraph below and below the statement.	
5.	Mention about game skill in the introduction.	YES
6.	Reference of Table 2 on page 7.	YES
	Already mentioned in the paragraph above.	
7.	Are we keeping any minimum criteria for PAR-Q?	YES
	Mentioned in the inclusion criteria	
8.	Are we maintaining any specific Heart rate zone?	YES
	Justification: We are providing training in different zones which will be decided by lactic acid level and heart rate.	
9.	References for reliability/ validity of instrumentation equipment?	YES
10.	Temperature in badminton court will be measured?	YES
11.	References of all treatment/ training?	YES

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EFFECT OF POLARISED TRAINING ON PHYSICAL AND SKILL PERFORMANCE IN ELITE AND SUB-ELITE BADMINTON PLAYERS

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